A New Quantitative Method to Evaluate Adnexal Tumors

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SUMMARY

Objective: The purpose of this study was to assess endometriomas and follicular cysts using a new quantitative method provided by the picture archiving and communication system.

Materials and Methods: We reviewed our computer ultrasound database of endometriomas and follicular cysts between November 2003 and July 2007. A total of 123 consecutive women diagnosed with an endometrioma or follicular cyst on two-dimensional sonography were re-evaluated using new parameters with the picture archiving and communication system. We chose quantitative tumor density and standard deviation on sonographic images as the new diagnostic parameters. Analysis of variance and Scheffé *post hoc* test were analyzed to compare the mean tumor density of the endometriomas and follicular cysts. The receiver operating characteristic curve was plotted to choose the cutoff value of the endometrioma tumor density with the best sensitivity and specificity.

Results: There was a significant difference when the tumor density of the follicular cyst and endometrioma groups was compared using the vaginal, abdominal or endovaginal approach ($p < 0.001$). Based on the results of the receiver operating characteristic curve, endovaginal ultrasonography is an excellent diagnostic tool with which to evaluate endometriomas. With endovaginal ultrasonography examination, the best cutoff value of tumor density is 28 and the sensitivity and specificity are 64% and 100%, respectively.

Conclusion: The use of quantitative tumor density and standard deviation on sonographic images is a potential new diagnostic tool in the assessment of endometriomas and follicular cysts. [*Taiwan J Obstet Gynecol* 2010; 49(1):45–49]

Key Words: endometrioma, follicular cyst, picture archiving and communication system, standard deviation, tumor density, ultrasound

Introduction

It is sometimes difficult to make an accurate diagnosis of adnexal tumors. The preoperative assessment of an adnexal mass is still a diagnostic challenge [1,2]. Accurate preoperative assessment of endometriomas [3] and follicular cysts can avoid unnecessary surgery. Optimal surgical intervention is of utmost importance in the case of endometriomas. The decision to treat with danazol or gonadotropin-releasing hormone agonists is dependent on the pathology of the endometrioma. Thus, the accurate diagnosis of endometriomas and follicular cysts has a major impact on treatment. In the case of follicular cysts, laparoscopic surgery is usually unnecessary.

The sonographic appearance in 95% of endometriomas has been studied in a retrospective review [4]. This study noted that adnexal masses with diffuse homogeneous internal echoes, as well as hyperechoic wall foci and multilocularity without other neoplastic features, were 32 times more likely to be endometriomas than any other adnexal lesion.

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At present, several parameters are available to distinguish endometriomas and follicular cysts. Gynecologic history, pelvic examination, cancer antigen (CA) 125 level, morphology on ultrasonography, and two-dimensional (2D) grayscale imaging [1,5] are all known to contribute to preoperative diagnosis. These parameters have been combined in diagnostic models. Although initial publications have reported an almost perfect performance of these models, a new assessment of adnexal masses with the picture archiving and communication system (PACS) has been designed.

This potential new diagnostic tool for the assessment of endometriomas and follicular cysts reveals tumor density and standard deviation in adnexal mass. The PACS achieves this by quantifying the 2D grayscale image of endometriomas and follicular cysts by calculating image adnexal tumor content. Tumor consistency and density in ultrasound images are potentially important parameters to distinguish follicular cysts from endometriomas. However, the density and standard deviation of the tumor image is not routinely available in daily clinical practice, and before introducing this diagnostic tool, it is important to know whether the use of the density and standard deviation of the tumor image has added value beyond the results of medical history, CA 125 level, and tumor morphology on ultrasonography.

The aim of the present study was, therefore, to evaluate the additional value of the density and standard deviation of the tumor image in the prediction of endometriomas and follicular cysts, thus allowing the estimation of the probability of endometriomas using PACS.

Materials and Methods

Between November 2003 and July 2007, 123 consecutive women with the diagnosis of an adnexal mass on conventional 2D sonography were asked to participate in this study. We retrospectively reviewed 109 cases of endometriomas and 14 cases of follicular cysts. The mean patient age was 36.1 years, with a range of 18–52 years. All the patients involved in this study were premenopausal. Pregnant patients with endometriomas were excluded.

Every case was initially evaluated using 2D sonography performed on a LOGIQ 9 system (GE Healthcare, Milwaukee, WI, USA) with a 7–9 MHz endovaginal probe. A transabdominal probe (5–7 MHz) was also used for large tumors. Seventy-five and 34 cases of endometriomas were examined by endovaginal and transabdominal probes, respectively. Eleven cases of follicular cysts were evaluated by endovaginal probe, and three cases were evaluated by transabdominal probe. After 2D sonography was performed, all the ultrasound images were analyzed using the Centricity PACS (GE Healthcare). We used the PACS software (Centricity Enterprise Web V2.1; GE Healthcare) to construct the data for the prediction of endometriomas and follicular cysts.

The morphology of tumors was described as cystic-like with septum formation. The analysis data included the density and standard deviation of the tumor image assessed using the PACS. In every selected case, the central area of adnexal tumor in the PACS image was circled. Then, the density and standard deviation of the adnexal tumors were obtained using Centricity Enterprise Web V2.1. After the diagnosis of adnexal tumors was made, surgery was arranged. Ovarian tumor enucleation through laparotomy, laparoscopic cystectomy and laparoscopic ovarian tumor enucleation were performed, depending on the choice of gynecologist and patient preference prior to the procedure. CA 125 level was measured before surgery for potential malignant evaluation. All adnexal masses were sent to a pathologist for a definite paraffin histologic diagnosis.

Analysis of variance and Scheffé *post hoc* test were used to compare the mean tumor density of endometriomas and follicular cysts on sonographic images measured from endovaginal and transabdominal approaches. The sensitivity and specificity on diagnosis of endometriomas by tumor density were also analyzed. A receiver operating characteristic (ROC) curve was also plotted to determine the optimal cutoff value of endometrioma tumor density (Figures 1 and 2).

Results

After surgical removal, 14 tumors (11.38%) proved to be follicular cysts and 109 (88.62%) were shown to be endometriomas. The average tumor size of endometriomas measured was 4.55×6.76 cm using the endovaginal approach, and 5.15×6.74 cm using the transabdominal approach. The mean size of follicular cysts was 3.64×5.20 cm and 3.78×4.80 cm, as measured from the endovaginal and transabdominal approaches, respectively.

Data analysis showed that the average density of the follicular cyst group using an abdominal approach on the PACS was 24.56 ± 13.63. The mean of the standard deviation of follicular cyst density using the abdominal approach was 24.67 ± 11.83. From an endovaginal approach, the average density of the follicular cyst group on the PACS was 9.55 ± 9.06. The mean of the standard deviation of follicular cyst density from

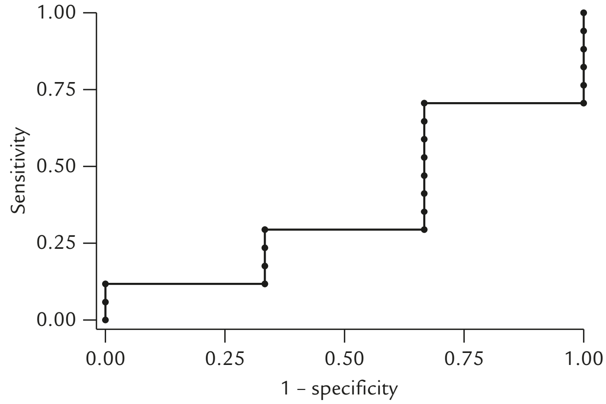

Figure 1. Receiver operating characteristic curve of endometrioma tumor density measured by transabdominal sonography. The area under the receiver operating characteristic curve is 0.3725.

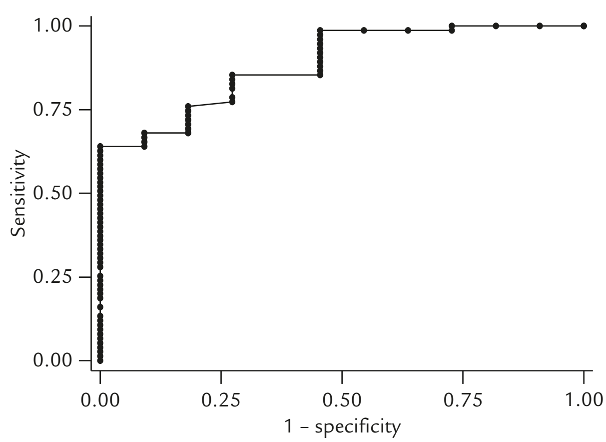

Figure 2. Receiver operating characteristic curve of endometrioma tumor density measured by transvaginal sonography. The area under the receiver operating characteristic curve is 0.8867.

Table 1. Characteristics, tumor size, average tumor density, and standard deviation of follicular cysts on the picture archiving and communication system (PACS) image*

	TAS ($n=3$)	TVS ($n=14$)
Age (yr)	38.00 ± 17.44	37.18 ± 8.35
Tumor size (cm)	3.78 × 4.8	3.64 × 5.20
Tumor density†	24.56 ± 13.63	9.55 ± 9.06
Standard deviation‡	24.67 ± 11.83	22.09 ± 3.72

Data are presented as the mean ± standard deviation; †tumor density on PACS image; ‡tumor standard deviation on PACS image. TAS = transabdominal sonography; TVS = transvaginal sonography.

Table 2. Characteristics, tumor size, average tumor density, and standard deviation of endometriomas on the picture archiving and communication system (PACS) image*

	TAS ($n=34$)	TVS ($n=75$)
Age (yr)	34.53 ± 10.02	36.55 ± 6.05
Tumor size (cm)	5.15 × 6.74	4.55 × 6.76
Tumor density†	22.88 ± 18.90	41.74 ± 27.00
Standard deviation‡	25.97 ± 3.66	23.65 ± 3.96

Data are presented as the mean ± standard deviation; †tumor density on PACS image; ‡tumor standard deviation on PACS image. TAS = transabdominal sonography; TVS = transvaginal sonography.

an endovaginal approach was 22.09 ± 3.72 (Table 1). Average tumor density in the endometrioma group using an abdominal ultrasonographic approach was 22.88 ± 18.90, with the mean of the standard deviation being 25.97 ± 3.66. Endometriomas from the transvaginal approach revealed the average tumor density to be 41.74 ± 27.00 and the mean standard deviation was 23.65 ± 3.96 (Table 2).

We used analysis of variance and Scheffé *post hoc* test to compare tumor density. Follicular cysts from the vaginal approach group were significantly different when compared with the endometrioma group, whether based on an abdominal or endovaginal approach ($p < 0.001$). We were easily able to distinguish between follicular cysts and endometriomas.

In order to diagnose endometriomas using sonographic images, we attempted to obtain the cutoff value of tumor density of endometriomas from abdominal and vaginal approaches. The sensitivities and specificities were also calculated. The results were plotted by ROC curves (Figures 1 and 2). For the endometrioma group using an abdominal ultrasonographic approach, the area under the ROC curve was 0.3725. By this examination, the cutoff value for tumor density was 12.8 and the sensitivity and specificity were 70.59% and 33.33%, respectively. The area under the ROC curve following an endovaginal approach was 0.8867. The optimal cutoff value of tumor density following an endovaginal ultrasonographic approach to evaluate endometriomas was 28. In choosing this cutoff value, the sensitivity and specificity was 64% and 100%, respectively. According to the results of the ROC curve, an endovaginal approach during an ultrasonographic examination to evaluate endometriomas appears to be an excellent diagnostic tool when compared with the abdominal approach. Thus, this optimal imaging process facilitates the diagnosis of endometrioma.

In summary, data analysis revealed that there were no significant differences for standard deviation on PACS images when comparing endometriomas and follicular cysts; however, there was a significant difference in tumor density between these two benign ovarian tumors.

Discussion

According to the morphologic study of ultrasonographic images, ovarian tumors can be described as cystic, solid, and complex [6]. Malignant ovarian tumors have specific sonographic images [1,5], such as septa, solid parts, and papillary growths within the tumor. Most endometriomas and follicular cysts are homogeneous tumors. It is important to recognize that endometriomas and follicular cysts may appear cystic-like in sonographic images.

A prospective study [7] proposed that the positive predictive value of sonography in the diagnosis of surgically-proven endometriomas was 91.5% overall and 97% for classic-appearing endometriomas (regular margins, round shape, homogeneous internal echoes, and thick walls), but the positive predictive value was only 70.9% for atypical-appearing lesions (irregular margins, anechoic appearance, and internal septations) [8].

Endometriomas generally contain punctate calcifications in the walls of the lesion; however, central calcifications of endometriomas are also recognized. Therefore, although teratoma is always diagnosed by the presence of focal calcifications, this does not exclude an endometrioma [9]. Some atypical endometriomas may be incorrectly diagnosed as a malignancy, especially in pregnant women with decidualized endometriosis [10]. Under this situation, the sonographic image of the endometrioma is characterized by solid, vascularized components arising from the wall and extending into the cyst [11]. Color Doppler sonography is not an ideal method to distinguish decidualization of endometriosis from malignancy, because flow can be found in the decidualized tissue.

For the purpose of diagnosis, the tumor marker, CA 125, can be measured to support the malignant probability of an ovarian tumor. It can be utilized to distinguish endometriomas from follicular cysts. This marker is not diagnostically useful for pregnant women [12], because CA 125 levels are elevated during pregnancy, especially during gestational weeks 11–14.

In addition to morphology, we have created new parameters to evaluate ovarian tumors, such as tumor density. Traditionally, the density of ovarian tumors on ultrasonographic images is classified as hyper- or hypodense [9], representing a qualitative illustration of the ovarian tumor image. We have used quantitative methods to evaluate the characteristics of ovarian cystic tumors. Furthermore, new concepts to improve the diagnosis of adnexal masses have been advanced. The aim of this prospective study was to determine new parameters, including the density and standard deviation on ultrasonographic images, of ovarian cystic masses. These quantitative data were calculated by means of the Centricity Enterprise Web V2.1 software provided by the PACS of GE Healthcare.

The tumor density in ultrasonographic images, as seen on adnexal mass images, was equal to the pixels from the PACS. Thus, pixels can be used to quantitatively represent the density of the tumor image on ultrasonography. When the ovarian cystic mass is denser, the number of pixels on PACS is increased, and vice versa. There is some difference in the viscosity of the tumor content between follicular cysts and endometriomas. When the percentage of protein in the tumor increases, the echogenicity of the mass will become denser and more hyperechoic. For example, follicular cysts have less protein content, and are, therefore, more clear and hypoechoic compared with endometriomas. Therefore, in conclusion, an obvious difference can be observed in tumor density between these two different tumors.

Another parameter, the standard deviation of the tumor image on ultrasonography, refers to the homogeneity in the ovarian cystic mass. Both follicular cysts and endometriomas are homogeneous ovarian tumors. According to our study, there was no significant difference in the standard deviation between these two masses.

Our study also revealed that the tumor density of follicular cysts on the PACS was within 10; on the other hand, the tumor density of endometriomas was always above 10, even reaching 50. Furthermore, the tumor density of an old endometrioma is higher while a fresh endometrioma presents with a lower tumor density. In summary, our studies indicate that tumor density measured on PACS is an excellent parameter for making a differential diagnosis in homogeneous tumors, such as follicular cysts and endometriomas. With this new assessment, unnecessary operations can be avoided.

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